

DOCUMENT RESUME

ED 415 833

IR 018 683

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TITLE Self-Teaching Student's Manual for Geographic Information Systems (GIS).
PUB DATE 1996-04-00
NOTE 11p.; Paper contributed to the Teaching in the Community Colleges Online Conference, "Innovative Instructional Practices" (1st, Kapiolani Community College, April 2-4, 1996).
AVAILABLE FROM <http://leahi.kcc.hawaii.edu/org/tcc/conf96>
PUB TYPE Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE EDRS Price MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Computer Oriented programs; Foreign Countries; Geography; Higher Education; *Independent Study; Information Technology; Instructional Innovation; Instructional Materials; Learner Controlled Instruction; *Material Development; Self Management; Skill Development; *Study Guides
IDENTIFIERS Australia; *Geographic Information Systems

ABSTRACT

This paper is a report of a project that was undertaken to produce a self-teaching manual for students wishing to acquire technical skills in Geographic Information Systems (GIS). Such skills are required in the analysis of locational data such as those found in aerial photographs, satellite images and digital maps. The self-teaching manual includes theory, applications and sample data sets for practice exercises. Such a manual is designed to shorten the learning time necessary to master the technical aspects of the software that is being used to analyze the spatial data. The technical skills are imparted in an interesting way using everyday examples. The manual will also appeal to social scientists, landscape architects and environmental managers and planners who have little or no background in GIS and information technology. Part 1 of this paper describes the objectives and teaching innovations that have been introduced. Part 2 discusses some of the successes of such an approach, as well as some of the difficulties that have been encountered. Part 3 summarizes some lessons and observations with the self-teaching approach and the alternatives to teaching and learning of technical skills and subjects. (Author)

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SELF-TEACHING STUDENT'S MANUAL FOR GEOGRAPHIC INFORMATION SYSTEMS (GIS)

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ABSTRACT: This paper is a report of a project that was undertaken to produce a self-teaching manual for students wishing to acquire technical skills in geographic information systems (GIS). Such skills are required in the analysis of locational data such as those found in aerial photographs, satellite images and digital maps. The self-teaching manual comprises of theory, applications and sample data sets for practice exercises. Such a manual is designed to shorten the learning time necessary to master the technical aspects of the software that are being used to analyse the spatial data. The technical skills are imparted in an interesting way using everyday examples. The manual will also appeal to social scientists, landscape architects and environmental managers and planners who have little or no background in GIS and information technology. Part one of the paper describes the objectives and teaching innovations that have been introduced. Then part two discusses some of the successes of such an approach as well as some of the difficulties that have been encountered. Part three summarizes some lessons and observations with the self-teaching approach and the alternatives to teaching and learning of technical skills and subjects.

INTRODUCTION

Geographic Information Systems (GIS) is an intuitive way of viewing and working with spatial data. It can present vast amounts of data concerning the "where" component, something which simply cannot be achieved using other database technologies. Geographical relationships are often critical in strategic planning, for example in market analysis where there is a need to know where the business is coming from, where to target advertising efforts, where competitors are located, the distance customers have to travel and so on. In general people relate much better and more quickly to maps and graphics than documents, texts and tables. The potential for GIS is being realised in the business world including insurance, banking, telecommunications, marketing, transport, building maintenance and distribution and advertising. World-wide GIS accounts for over \$10 billion dollars in sales and services. GIS is becoming an indispensable tool for planners and managers at all levels of responsibility.

The need for an independent series of modules has arisen from two sources. Higher level students, for example third year, honours or postgraduate students who may not have been exposed to GIS in their previous studies may need to acquire GIS skills in a

hurry to help in their present studies. This is the result of technology marching ahead in such rapid strides that many are unable to keep up with the pace. Another reason is that the study programmes of many students are already full to the extent that they are unable to fit in another useful techniques unit. Yet these students find the need to learn about GIS in order to extend prior studies. A self-teaching manual will fill the needs of such students.

PART ONE. OBJECTIVES AND TEACHING INNOVATIONS

Objectives

This project has produced a self-teaching manual to develop technical skills required in understanding and using GIS. The manual is made up of five modules. Each of the modules include the necessary materials such as student workbooks, notes, data sets and problem exercises. Students will need to have access to a personal computer and have a functional knowledge of using computers. The platform used here is the PC or compatible machines because the GIS software used has been written for that platform. The modules are self-contained and have been produced as hardcopy documents using desk top publishing techniques as well in digital form stored on a network server (Novell LAN) and on floppy disk in compressed form.

Integration into the Total Teaching Process

The process of transferring knowledge and skills begins, firstly, with the introduction of ideas and problems and secondly in translating these into practical exercises. The main feature of this project is to use practical examples from everyday life experiences and then incorporating these into a spatial information framework. The planning of one's daily journey to work, the layout of a home garden or the more complex management of a park environment for native flora and fauna are some examples.

At the University of Canberra the modules have been used in Resource Information Systems and GIS in the School of Resource, Environmental & Heritage Sciences and its use is planned for use in the Faculty of Environmental Design's Landscape Design and Planning course and in the Economics and Marketing streams of the Faculty of Management. Why this forms an essential part of the teaching programme is apparent from the nature of the subject matter itself, namely: spatial information and analysis, geodemographics and business geographics.

Practical Improvements in Teaching

Learning about GIS can be fascinating where it is introduced and presented as discrete components of a whole. Once a component is understood and brought together with other components a perception of the big picture begins to form. Similarly, while the basic principles of analysing spatial data are easily understood, novice students may have difficulty dealing with conceptual issues and unfamiliar computer operating

systems. The teaching method adopted in each of the modules, thus, is to employ a **spiral curriculum** so that, progressively, the student is taken from basic principles to more depth and insight at the end of the module. The next cycle begins from this point on to even more complex ideas built from the previous cycle.

Four improvements to teaching should be made apparent. First, solutions to problems posed in the literature are given. Second, case studies form the core of examples of applications in the field. Third, a glossary of concepts, an index and real-world applications of GIS is given to provide the contextual background to the various GIS functions. Finally, there is a 'Help Desk' utility which may be accessed in digital form on floppy disk and read by any text or word processing software. The intention here is to provide as much information in as many varied ways as possible to keep up student interest and pose various challenges to students. By mimicking examples given in the case studies and using solutions to practical problems discussed in the literature, students may learn by proxy. This is especially useful in a technology-based project such as this.

PART TWO: SOME SUCCESSES AND SOME DIFFICULTIES

The impact on student learning was gauged through an active feedback program involving a questionnaire every time a module was completed and then at the end of the semester when all the modules had been attempted. It was anticipated that the impact on student learning would have been considerable given their active involvement and their completion of GIS tasks after reflection and thought. Solutions to case problems given in the modules were obtained only through discussion, reading and research. The teaching materials provide only the skeletal outline to a solution. Such a modular design in the delivery of learning materials meant that students could take their own time and advance at their own pace irrespective what others in the class were doing.

The modules have been designed in such a way that students are given the opportunity to take an active part in their own learning. Generally students were expected to do some reading, some basic research, partake in a computerised demonstration, complete an exercise and then write up their results. These five steps are the basic requirements for a successful completion of a module. Given this sequence an 'average' student should take about 10 hours to complete one module with each activity being about 2 hours. Where relevant reading material has been included in the workbook for quick access and for future reference. Demonstrations, exercises and basic data have been provided on floppy disks while the results of practical work are written in exercise books for the tutor to evaluate.

Because of the way the modules are organised, Module 1 has to be completed first since it provides the background and foundation to the whole study programme. Likewise, Module 5 has to be completed last as it is a capstone unit which "ties up the loose ends"

and provides suggestions for further development and applications of GIS. Modules 2, 3 have to be completed before module 4 since these contain the technical skills and discrete items of information which may be assimilated.

The Modules

Module 1: Geographical Information Systems (pages)

Module 2: Introduction to Raster GIS (pages)

Module 3: Introduction to Vector GIS (pages)

Module 4: Managing Attribute Data (pages)

Module 5: Integrating GIS and Remote Sensing (pages)

A questionnaire for evaluating the teaching modules and student's views and suggestions have been included with each module. It is hoped that these will enable feedback on improvements to the material as presented. The University of Canberra's Centre for Teaching and Learning (CELTS) has provided expertise for the monitoring and evaluation of the implementation of this project.

Some Successes

Having all the reading and learning material between two covers of a module gave a broad overview of the subject-matter of GIS. Students therefore need not take copious notes either during a lesson in class or when doing private reading in their own time. This security of having it all there in the modules meant that the students could concentrate their attention on learning the technical skills themselves rather than be distracted by other extraneous matters. The hands-on experience has been well-received by the students. Initially it was thought that this may have come from the Chinese belief which says:

"I hear, I forget;
I see, I remember;
I do, I understand".

However, this advice is at best a half truth and may be outmoded. A distinguished Hong Kong gynaecologist has recently suggested a better version for his students which says:

"I hear, I forget;
I see, I remember;
I **make a mistake**, I understand".
(See Ramsden, 1992: 263).

The use of examples of the applications of GIS taken from everyday living was extremely valuable in the retention of ideas and concepts. This may be because the

students could relate to the various situations and that the examples were their own 'lived' examples. The connection between doing (practising) and understanding a concept is direct, overt and very real. This aids in remembering as well as associating experiences to concepts. The material introduced especially the technical skills and how these could be related to what previously was done by pen and paper and by hand proved most instructive. Again this may have been because the students could see the relationship between doing something by hand, such as drawing a map, and the various instructions that would be required to 'tell' a machine how to draw the same map. The difficulties and the mistakes in the 'telling' itself was most beneficial because it made students realise that while conceptually simple the actual translation into instructions could be very difficult. As an extension to this discussion, some students found the materials introduced here very relevant in their various courses of study.

The layout of the modules and the presentation of materials in terms of linkages to different modules was well received. The logical links between the different modules could easily be seen in the structure and organisation of each module. A diagram summarized the structure and organisation of the modules in the manual. Linkage diagrams made these connections easy to understand. Moreover, each module was organised in the same structure as any other so that the students could expect to find what they were looking for easily. There is no room for 'surprises' or different treatments of the subject-matter. While it made the presentation somewhat mechanical, it had the effect of consistency and a feeling of gaining progress and knowledge spiralling upwards. It is believed that in the electronic versions of the modules that are being planned for further work, some system of 'hyper-texting' the material could be included. Already experiments using Visual BASIC has shown that it is possible to mimic the hypertexting that is commonly used on Internet viewers such as Netscape and Mosaic.

The innovative use of different styles of illustration such as using diagrams only instead of just text, lots of diagrams, flow charts and tables to illustrate ideas all help in delivery of the material. Students have found the manual provides a good introduction to GIS technology and to spatial analysis in particular. However, there were some reservations as noted in the next section.

PART THREE: LESSONS AND OBSERVATIONS

Some Lessons

As GIS was a new subject to many students there were many new concepts, terms and words to grapple with. As a result reliance on the glossary and index would be insufficient. Additional aids such as the illustration of concepts and ideas simplified as dot points, diagrams, pictures and more examples were necessary. The use of images was particularly difficult given that these had to be of printable quality in monochrome

if it was to be included in the manual. However, when these were merely for display on a computer monitor then the problem may disappear.

As noted previously there were five modules in this Manual. Altogether the total number of printed pages amounted to about 300 A4 printed pages. Many students perceived that there was too much to read and hence too much to do. Some said that the material was interesting but a semester is too short to do it in. At the University of Canberra a semester is 15 week long with a short mid-semester.

The need to discuss and to debate is at odds with the self-teaching philosophy espoused in this project. Face-to-face contact is especially important when more difficult technical skills is to be imparted. The printed page is linear and unidimensional whereas a tutor with a group of students in front of a computer monitor allows a multidimensional multimedia interaction and discourse. Questions, uncertainties and queries could easily and quickly be fielded so that misconceptions and misunderstandings are prevented from being carried forward into the other lessons and modules. It is important that tutorials and practical classes where there is student-teacher interaction is indispensable in imparting technical skills and knowledge.

The problem of student learning a technical skill is exacerbated by the fact that there may be elements of computer illiteracy. This is especially so where the modules assume some prior computer skills from the most basic such as file naming conventions in MS-DOS through to file operations of file transfers, file conversions and the like. Difficulties here may spill over to other areas of learning. Rather than encouraging student learning, some may be turned off and these students may become lost to the class and may become a statistic in the attrition rate. In addition to the time constraint of the semester the pressure and stresses laid on students can become enormous especially when other subjects also require equal time and attention. However, in order to be truly instructive, there is a need for more time between modules to think, to reflect and to assimilate the newly acquired knowledge.

There are also some lessons to be had from the physical production of the manual itself. Good manual writing starts with basics. At a minimum a title, table of contents with clear section dividers and colour coded tabs is required. Colour coding covers will help as well as a standard template layout of the material. In the printed materials, wide margins with extensive white space and margins (up to 50 per cent of each) page will be more easily read than one where the text is closely spaced and is in small type. At a minimum the font size should be at least 12 points and preferably **sans serif** for easy reading. In future the modules should also be produced loose-leafed so that there can go into ring binders of one kind or another. This has two advantages. First, updates can be easily accommodated as bound versions of the manual only invite up-date confusion. Secondly, in loose-leaf form the modules will lie flat and this is especially so when the desk-top has to accommodate the modules, the keyboard and a computer monitor and

other accessories.

New technical words, terminology and acronyms should be defined on its first usage. These should be repeated in a glossary as well as in the index. Ensure that page numbers for these terms are entered accurately in the index because there can be great frustration when there is inaccuracy in the index. Reference to other sources for these terms would be useful because the student may also be exposed to a different way of defining and expressing these terms and may actually prefer those in the references to those given in the modules. It is thus very important that the glossary and index become a central feature of the manual and to ensure that the technical terms used are clearly defined. Alternatives to the definition will also help in understanding and learning.

It has been suggested that as academic teachers we may have become too close to the subject to be able to write clearly either because of the volume of material we may wish to include or because we take for granted some essential item without realising it. Thus, one way to overcome this is perhaps to hire a technical writer(s) to help put the documentation in order and to produce a professional result. The writing of instructions and procedures is a highly skilled task and not every one is able to do this properly. Yet, this is the most important task to the whole project.

Some Observations

That learning is a key to good teaching. This is as important for teachers as it is for students. A good teacher is one that has 'learnt' well. Writing on an overhead projector slide or on the white board in front of the class may encourage students to take this down. Why, because they may wish to reproduce this later on when asked in a test. This may encourage what has been described as 'surface learning'. However, deep approaches to learning aim at understanding. When something is written on the white board, students using a deep approach will relate it to what they already know, including the elements of the present unit or other unit. These students say that it is easier to remember when they relate it to their own life experiences, real or imagined. Teaching technical skills should encourage this form of learning and making mistakes in the process may be the key to understanding and to remembering.

Teachers must have a good understanding of the subject matter and also how information is learnt and retrieved and the circumstances which contribute to the best results. The learning environment contributes greatly to student learning by giving direction and guidance. This way the class discussion points to things students should look for so that the more open ended the assignment the better the learning experience. Autonomy and self-direction may encourage deep approaches to learning. However, this approach needs to be used carefully because it may not work with beginning or first year students who may still be looking for guidance to do specific projects.

A further observation is that of the diversity of the student population. There may be

more than one way of describing a process or procedure. There may be diverse ways of defining a concept. While it may border on repetition, saying things more than once and in different ways may be a good rule of thumb to follow.

Some experiences coming out of using the modules suggest that there may indeed be different types of learners:

Visual learners want information they can see; they prefer a map or a drawing;

Auditory learners want information they can hear; and

Kinesthetic learners want to be physically involved. They want to be totally involved.

The diversity of the student body also suggests that there could be **global** and **specific** types of students. Some prefer the big picture initially than the details. Others prefer to know all the details leading up to the climax of the big picture. While still others prefer to be told precisely how to get there whereas to another group of students the journey to get there is the whole point of the exercise.

CONCLUSION

This project has been an interesting exercise in the attempt to free the teacher to provide closer attention to specific segments of a student body. By having all the material in printed form both the teacher and the student are given the opportunity to concentrate on the the important tasks of teaching and learning respectively. But this has not been the case because of a number of factors. The writing of the manual is time consuming and a demanding task. The development time and the writing of the narrative is not as easy as first thought. Not only has the prose be made simple, it has to be concise -- a task made doubly difficult with a technical subject such as GIS.

There is room for a variety of media in the dissemination of knowledge and information and this includes the teacher, the manual and reference books, the modem and the computer with the appropriate software. To concentrate on one or the other may only partially achieve the objectives of the project. But there is no denying that the teacher is in the best position to respond to the needs of an audience. No amount of electronic wizardry and reference material may replace the friendly and not-so-friendly face to help students learn. Here how the teacher reacts to different learning situations especially the teacher's own may provide a good beginning as to how students themselves learn. Such things as concentration, note taking, logic in constructing written work, recalling information accurately, understanding what others are saying and causes of frustration may help in heightening the student learning experience. Making more positive use of these may help good teaching in the longer term.

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ACKNOWLEDGMENT

I wish to acknowledge the financial assistance of the Committee for the Advancement of University Teaching (CAUT) of the Australian Department of Employment, Education and Training (DEET) who kindly provided a teaching development grant in 1995 to undertake this project. In addition I wish to thank the many students who participated in this project and gave their valuable comments and criticisms in the development of the various modules. Also the School of Resource, Environmental & Heritage Sciences at the University of Canberra, Australia provided a conducive and encouraging environment to pursue this project.
